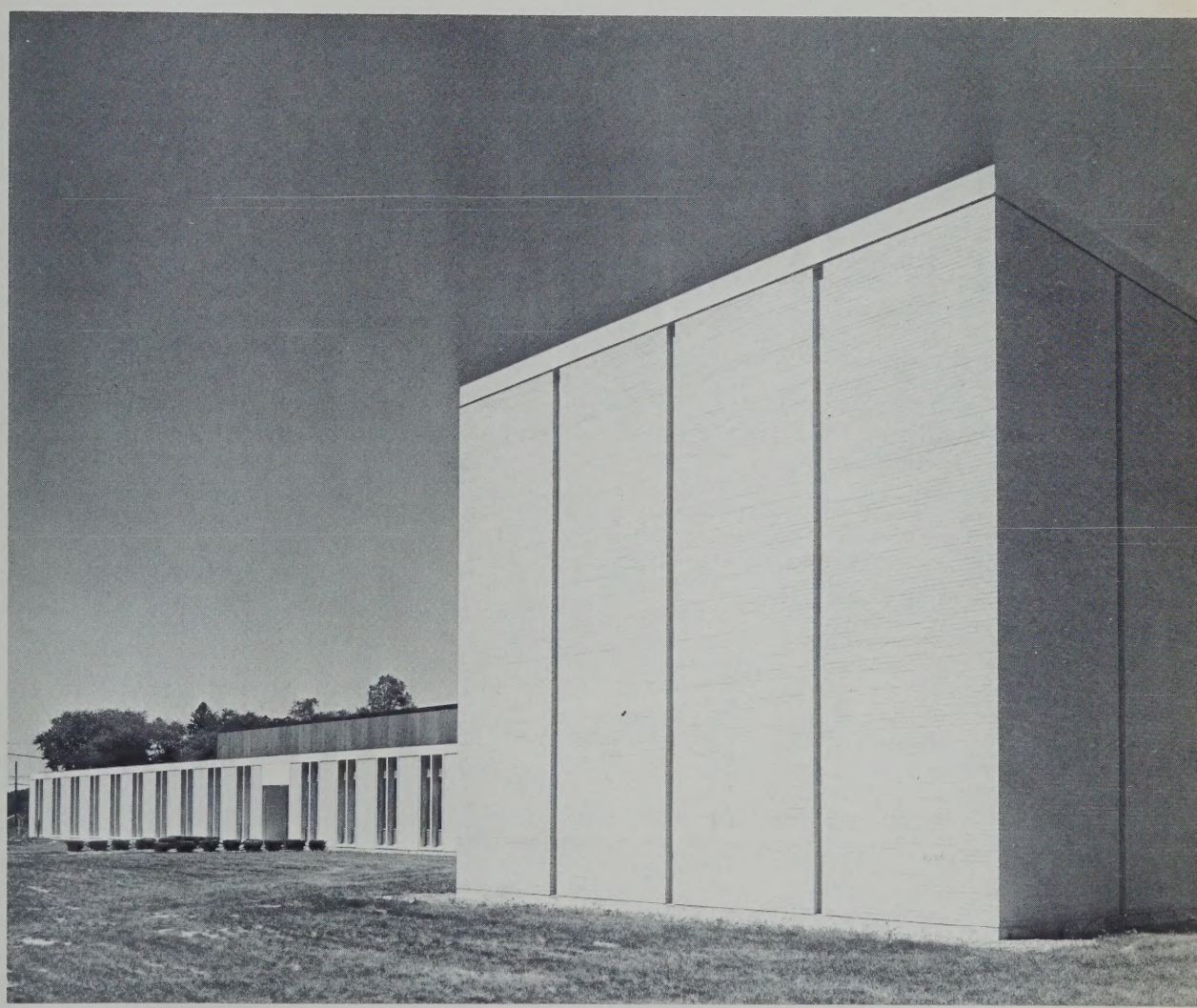
NATIONAL BUREAU OF STANDARDS December/1968

# Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

# Technical News Bulletin

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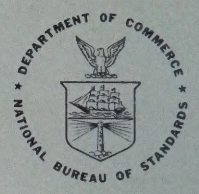


U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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**COVER:** *The recently completed Sound Laboratory at NBS is dominated by its reverberation chamber (right). A ring of offices encircles smaller laboratory modules to minimize the intrusion of outside noises.* *(See page 274.)*

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- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research

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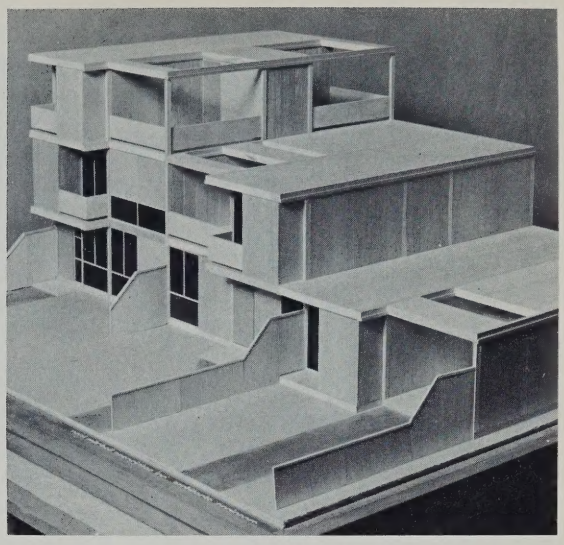
# FIRST CONFERENCE ON MAN AND HIS SHELTER

## *Performance of Buildings—Concept and Measurement*



*Scale model of the Phoenix Project for low-income housing in Detroit, Mich.*

The first in a planned series of conferences on "Man and His Shelter" was held at the Bureau's Gaithersburg, Md., laboratories September 23–25, 1968. The purpose of the Conference, entitled "Performance of Buildings—Concept and Measurement," was to bring together those people who are concerned with providing man his shelter—for homes, for work, for schools, and for entertainment. The exchange of ideas and knowledge, it was felt, would inspire these people to work together productively to solve one of man's oldest needs and one of today's most pressing problems. Comments from many attendees indicated that this purpose was successfully achieved. The Conference was coordinated by W. W. Walton, NBS Building Research Division.

One of the highlights of the 3-day Conference was an address by the Honorable Robert C. Weaver, Secretary of the Department of Housing and Urban Development, at the Conference banquet. He stressed the need for better housing and outlined the congressional action that has been taken in this area. Speaking on "Technology and the City: Closing the Gap," Secretary Weaver said, "America has huge problems in furnishing decent shelter for its people. We have made great strides in scientific and technical ability. Where we have fallen short—and this may be oversimplified—is in applying that ability to improving and increasing our supply of shelter."

The Conference was designed to cover a range of ideas within the broad and often misunderstood framework of "Performance." The *Introductory Session* set the stage for both the series and the Conference with a keynote address on the series, and talks on the importance of user needs and measurement in any consideration of "performance."

L. M. Kushner, Chief, NBS Institute for Applied Technology, welcomed the more than 250 attendees. J. P. Eberhard, Dean of the School of Architectural and Environmental Design at the State University of New York at Buffalo, then gave the keynote address in which he stressed the need for more efficient applications of science and technology. Mr. Eberhard said that new concepts are needed to produce buildings that can adapt to man's needs. He pointed out that a feedback of data, similar to that used in space research, is needed to learn from past mistakes.

J. R. Wright, Chief, NBS Building Research Division, followed the keynote address with a talk entitled "Measurement—Key to Performance." Dr. Wright pointed out the role that measurement plays in our society starting with the four basic quantities (mass, length, time, and temperature). He went on to say that in the area of building performance, measurement techniques are necessary to determine whether a desired performance level has been achieved. He also emphasized the need for both objective and subjective measurements (e.g., human response to test situations). M. Brill of NBS concluded the first session with a discussion of the primary importance of the "User in the Performance Concept." Any building that does not give first consideration to the user's needs is bound to be inefficient, inadequate, and frustrating to the occupant.

*continued*

*Robert C. Weaver, Secretary of Housing and Urban Development, was guest speaker at the banquet. Seated (left to right) : L. M. Kushner, Director, NBS Institute for Applied Technology, C. R. Smith, Secretary of Commerce, and A .V. Astin, NBS Director.*

The Monday afternoon session on *Evolution of Performance/Systems Method* began with a description of a building systems project, sponsored by the Public Buildings Service of GSA and currently in progress at NBS. R. W. Blake of NBS described the concept and rationale of the systems approach in a specific example of the design and construction of a Federal office building in the talk entitled "PBS Building Systems Project." The status of this project as well as an estimate of its future was presented. The implications of a successful conclusion to the project and wider applications of systems methods were also considered.

B. E. Foster of NBS covered "European Systems for Evaluation and Approval of Innovations in Buildings." In general, he said, the innovator goes to the evaluating body and discusses potential evaluative procedures and costs. He furnishes data on the innovation and experience with its use as well as the exact manner of intended application. Manufacturing facilities are then examined and an evaluation program is developed. Tests are made, usually in a government-operated laboratory, but in some countries by approved university, commercial, or trade association laboratories. The total information available is then evaluated by a committee of experts in the field. In this evaluation, judgment based on long-time familiarity with the properties of materials, and with their use in construction, is required in many cases to augment laboratory data.

Speaking on "Modular Coordination," R. W. Smith of NBS explored the unique and fundamental role of modular coordination in providing a basis for building industry metrology, standardization, and communication. Mr. Smith discussed the role of modular coordination in increasing productivity and thereby lowering costs. He also pointed out the need for national standards to serve as a format for the application of industrial efficiencies within the building process. The coordinating role of USASI Standard Committee A62, Precoordination of Building Components and Systems, was also discussed.[1]

Tuesday's sessions dealt with the feasibility and problems involved in measuring performance of entire structures and individual building components. The morning session, *Some Aspects of Low-Cost Housing*, began with an outline of the Federal Government's role in the area of low-cost housing. B. T. Craun, Director, Low Income Housing Demonstration Program, HUD, in a talk entitled "Goals and Intergovermental Cooperation in Low-Cost Housing," said that for the next ten years, the national housing goal is 26 million new units, which represents twice the present rate of construction. Six million of these units are specifically to be constructed for lower-income families. To accomplish this goal, a national investment in excess of 400 billion dollars will be required.

HUD undertook an experiment (Phoenix Project) in Detroit, Mich., that had as its goals: (1) to involve the lower-income people in important design considerations concerning their housing and (2) to test the time and cost of a new construction system showing a theoretical potential for significant cost reduction. Working with the City of Detroit Building Department and a Board of Detroit Professional Engineers, HUD solicited the aid of NBS, the Corps of Engineers, and the National Academy of Sciences to develop data.

This cooperative effort marks an important first in the accomplishment of this Nation's housing goals. A method was established that can serve as a model for introducing new and innovative technologies into our cities with confidence by all as to the safety of the system.

N. B. Mitchell, President of Neal Mitchell Associates, spoke on the "Design Aspects of a Low-Cost Housing System," in which he detailed the steps in the design and manufacture of the units for the Phoenix Project. For this system, emphasis was placed on user requirements and future flexibility and expansion. The user requirements were studied in the context of the unit, the neighborhood block, and the urban sector. The in-

*continued on page 281*

# SYSTEMATIC TRENDS FOUND IN ATOMIC OSCILLATOR STRENGTHS

Scientists at the National Bureau of Standards have detected systematic trends relating the atomic number and atomic oscillator strengths. Application of these relationships may substantially increase the reliability and the number of these atomic data. It should also aid in solving problems involving atomic properties in the fields of plasma physics, space physics, and astrophysics. The findings were principally made by W. L. Wiese,[1] of the NBS Institute for Basic Standards, in work supported by the Advanced Research Projects Agency on Project Defender, whose interests include the physical properties of the upper atmosphere with respect to satellite and missile communications.

The relationships became apparent in the course of an empirical study that was carried out in connection with a critical evaluation of atomic oscillator strengths found in the literature. During the program over 8000 individual data were collected and analyzed for the preparation of standard reference tables.[2] The oscillator strength, or f-value, is a measure of the spectral line intensity observed when an electron transition between two different atomic energy states takes place.

From the data they collected, the NBS scientists were able to demonstrate the following relationship: The oscillator strength for a given spectral line within an isoelectronic sequence varies systematically with the inverse atomic number.

As an example, let us consider the transition $3s^3S–3p^3P^\circ$ of the beryllium isoelectronic sequence. We start with neutral beryllium and plot the available oscillator strength (1.1) against the inverse of the atomic number (which is 4, so its inverse is 0.25) to obtain the first point on our graph. For the second point, we would plot the f-value of the same transition, but in singly ionized boron (B II, with atomic number 5), which has the same electron structure as neutral beryllium, against the inverse of boron's atomic number. However, for the case of B II, no f-value is available for this transition as yet. Continuing in this way, we plot the f-value of again the same transition, now in doubly ionized carbon (C III, atomic number 6) against the inverse of carbon's atomic number. The f-value of the corresponding transition of triply ionized nitrogen (N IV, atomic number 7) follows, then the relevant f-value for O V (atomic number 8); then the f-value for F VI (atomic number 9), which is not known yet; then the f-value for the same transition in neon with 6 electrons removed (Ne VII, atomic number 10), and so on, each plotted against the inverse of the atomic number. The resulting points should fall on a smooth curve.

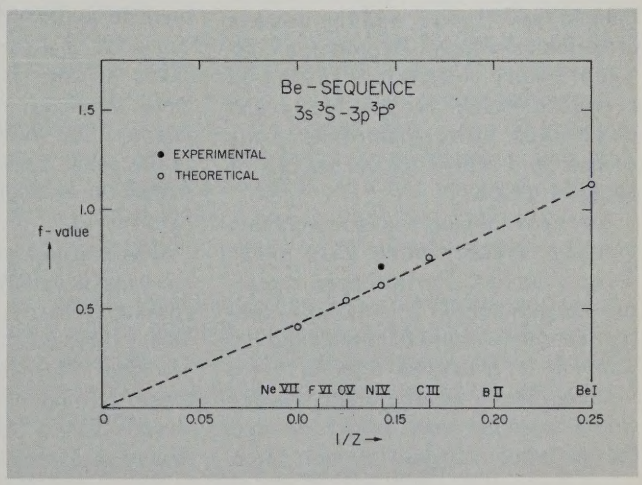
By making use of this relationship, which in its general form may be readily derived from conventional perturbation theory, scientists will be able to obtain by extrapolation or interpolation the f-values of transitions for which no experimental or theoretical data are available as yet, as in the example given above for B II, F VI, and all ions higher than Ne VII. The systematic trends will also greatly assist in judging the reliability of the data by observing their degree of fit into established trends (see, for example, the N IV point in the figure).

So far, data on oscillator strengths have been tabulated[2] at NBS for the elements from hydrogen to neon, and present analyses are bringing together data for the next 10 elements of the periodic table—from sodium to calcium. Up to now, more than 100 systematic trends have been definitely established by the data.

[1] Wiese, W. L., Dependence of atomic f-values on nuclear charge, Proc. Conference on Beam Foil Spectroscopy, Tucson, Ariz., 1967 (Gordon and Breach Publishers, New York, N.Y., 1968); Wiese, W. L., Systematic trends of atomic oscillator strengths in isoelectronic sequences, Appl. Opt., to be published; Wiese, W. L., and Weiss, A. W., Regularities in atomic oscillator strengths, Phys. Rev., to be published.

[2] NSRDS News: Atomic and molecular properties, NBS Tech. News Bull. 50, No. 6, 98–99 (June 1966).

*Data from the literature were plotted for the transition $3s^3S–3p^3P^\circ$ of the beryllium isoelectronic sequence. The oscillator strength (f-value) is plotted versus the inverse of the atomic number (1/Z).*



# FIELD STUDY OF FLOOR COVERINGS

One function of the Bureau is to determine, through investigations and tests, what types of materials and products are best suited for various applications by agencies of the Federal Government. Since the Government often must purchase large quantities of a product, a careful consideration of the product's expected performance can mean large savings to the taxpayer.

The Bureau has observed the performance of floor coverings in military installations for the past 13 years (1955–1968). Some civilian installations were also observed to gain a wider experience. This field study was sponsored by the Office of the Chief of Engineers, U.S. Army; Directorate of Civil Engineering, U.S. Air Force; and the Naval Facilities Engineering Command, U.S. Navy. Its object was (1) to evaluate types of floor coverings, (2) to assist the Department of Defense (DoD) with flooring problems, and (3) to gain background experience in floor coverings. This background is essential in defining areas of research designed to improve standards and specifications. In a research approach, conditions can be controlled, at least to a greater degree than in field studies, and the number of variables reduced. By studying only a few factors (ideally one factor) at a time, it should be possible to discover which factors contribute to the success and which to the failure of floor coverings.

The needs of DoD are unique in that military necessity often takes precedence over cost. For example, replacing a concrete floor in a mobilization-type company messhall costs about the same as a trowel-on type of resin topping. However, the resin topping can be installed more quickly, so that the training schedule is not interrupted. Also, DoD does not have time to conduct a basic investigation of the properties of floor coverings before making decisions as to which coverings to use. The policy has been to try various floor treatments or coverings and base decisions on the results. Such experiments have revealed failures caused by poor adhesion; inadequate substrate preparation; improper application; exposure to heat, water, food spillage, heavy wear; impact from boxes and trash cans; and other causes.

Some of the floor coverings generally known as decorative brush-on or roll-on monolithic flooring are more like a coating. These are relatively thin and are closely related to floor enamel. Another type of covering is mixed with aggregate in a concrete mixer or pail and is troweled on in the same manner as a concrete floor topping. A third type also resembles a concrete floor topping but the aggregate is decorative, usually marble chips, and the topping is ground after hardening with a terrazzo grinder.

The study is valuable from a flooring research standpoint because of the severe conditions often encountered in military installations and because of the variety of conditions. Many of the flooring installations were in Army messhalls, barracks' latrines, and shower rooms. Not only is the usage severe but the substrate is likely to be contaminated or subject to moisture.

Observations were made of 76 floor covering installations in 62 locations. Among these, 53 were in six Army posts between New Jersey and Georgia. The floor coverings were those normally used in messhalls, shower rooms, latrines, stairs, residences, and other areas.

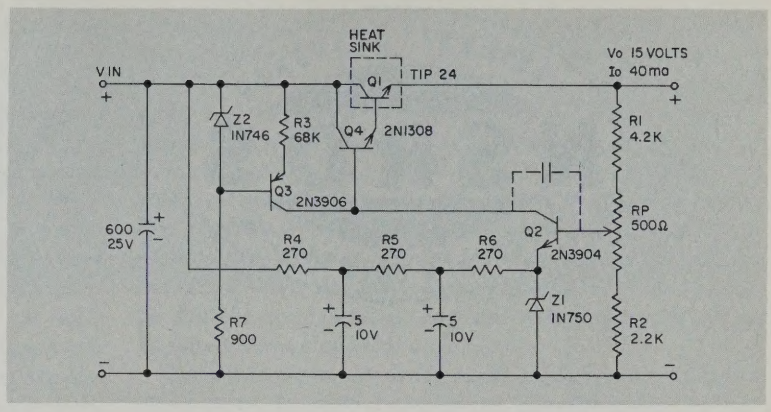
Fifty-six of the coatings were of synthetic resins, of which 52 were divided among epoxy, polyester, or polyurethane compositions. Two other coatings were of resilient tile and vinyl sheet goods; five coverings were of quarry tile. Modified hydraulic toppings accounted for the rest. The resin coatings were further subdivided into brush-on, trowel-on, and thinset terrazzo types of applications.

Most of the floor coverings were installed over concrete although a few were installed over plywood. The concrete floors were slabs on grade or suspended. In the histories of the coverings, details of surface preparation were included when they were known.

In the case of monolithic resin coatings, failures were generally due to loss of bond or adhesion between coatings and substrates. Since the substrate was usually concrete, this suggested a laboratory study of adhesion between resin systems and concrete. Such a study is currently in progress.

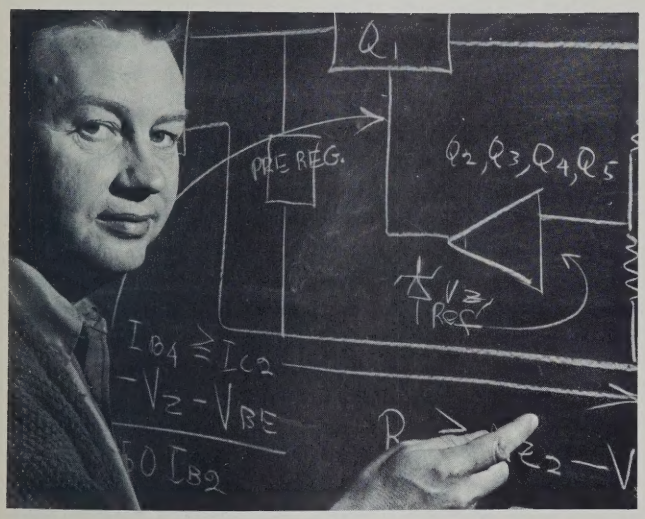
The study also showed that more bond failures occurred with epoxy and polyurethane resin compositions than with formulations based on polyester resin. This suggested a comparative study of these three types of resin systems. In addition, the more detailed portions of the results indicate the possibility of bond failures being caused by grease, moisture, and other contaminants, which suggests further study in this area. Because of the large number of variables associated with a study of this type, it was difficult to draw general conclusions. However, the summary contains many significant data on individual installations.

For more detailed information write to W. C. Wolfe, NBS Building Research Division, Rm. B358, Bldg. 226, Washington, D.C. 20234.




*A schematic diagram for a low-voltage regulator circuit made possible by the simplification and organization of design equations.*

# SIMPLE, INEXPENSIVE LOW-VOLTAGE REGULATORS




*J. H. Rogers develops a schematic diagram from simplified design equations.*

Since the transistor was introduced in 1948 it has evolved into a fundamental piece of electronic hardware. First used to construct compact, portable radios and hearing aids, the transistor is now applied extensively in more sophisticated circuits such as those in digital computers and satellite transmitters. Nevertheless, even advanced transistor circuitry requires regulated-voltage power supplies to minimize voltage fluctuations and ripple voltages that may damage or cause malfunctioning of the circuit.

Although design equations for voltage regulator circuits are available in many different texts and manuals, several such sources are often needed to get a clear picture of the appropriate procedure and equations to use. To reduce this confusion, J. H. Rogers of the NBS Institute for Basic Standards recently simplified and organized design equations for low-voltage regulators.[1] Using these derived equations, three types of transistorized regulator circuits in varying degrees of complexity have been constructed that are suitable for use in the range from 2 to 30 volts. The circuits are relatively simple, inexpensive, and compact (each regulator can be constructed on a 3 x 5 in plug-in card), and have proven to be dependable under laboratory conditions.

## *Design Equations Condensed and Organized*

Calculations were kept simple by proper choice of equations and by the inclusion of a variable resistor to compensate for the difficulty of obtaining the exact value of the resistors involved. This has also led to a reduction in the number of components required for construction of the regulators—the most complicated of the three types has only 16 parts.

One of many possible uses for the regulator circuits can be seen in the following problem in voltage regulation: To utilize the good stability of a small integrated circuit operational amplifier, a regulated dual $\pm 15$-volt power supply was needed. The design formulas were used to arrive at the component values, and two identical regulators were constructed. The two were then connected as a $\pm 15$-volt dc power supply that gave about 1 percent regulation.

In general, these simple and workable design equations should aid the scientist, engineer, and technician by making possible the construction of voltage-regulated power supplies with a minimum of design, material, and construction time.

[1] Rogers, J. H., NBS Technical Note 371 (Sept. 1968).

# NSRDS NEWS

*This column regularly reports significant developments in the program of the National Standard Reference Data System, which was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the NBS Office of Standard Reference Data.*

## Data Activities in West Germany

For many years the evaluation and compilation of data on the properties of substances have been a cooperative activity among the world's scientists. Two well known international compilations are the International Critical Tables and the Landolt-Börnstein Tables. While the former was an international undertaking from the beginning, the latter began as an entirely German effort.

To acquaint readers with some of these international efforts, *NSRDS News* has described such programs. The following description of data activities in West Germany was provided by Herbert Stussig, Vice Chairman, Federal Republic of Germany National Committee for CODATA.

Germany, with a long tradition in compiling and critically evaluating data, has produced four well known handbooks: Landolt-Börnstein's Zahlenwerte und Funktionen aus Physik, Chemie, Astronomie, Geophysik und Technik (Numerical Data and Functional Relationships in Physics, Chemistry, Astronomy, Geophysics and Technology); Gmelin's Handbuch der Anorganischen Chemie (Handbook of Inorganic Chemistry); Beilstein's Handbuch der Organischen Chemie (Handbook of Organic Chemistry); and Ullman's Encyklopädie der Technischen Chemie (Encylopedia of Technical Chemistry).

There are fundamental differences in the organization of the four handbooks. The Landolt-Börnstein tables are arranged according to the physical properties of the different materials and substances, whereas the Gmelin and the Beilstein handbooks are organized according to chemical substances. The Ullman encyclopedia essentially covers both aspects, but emphasizes technological application.

The *Landolt-Börnstein Tables* tries to be a comprehensive publication of all the best values of data compiled from the world's literature in physics, chemistry, and technology. As an accommodation to its many English-speaking users, the *New Series of the Landolt-Börnstein Tables* is published bilingually (German and English).[1]

The *Gmelin Handbook* published by the Gmelin Institute is probably the largest specialized compilation in West Germany. It also is probably the oldest work, having first been published in 1817 by Leopold Gmelin. The present edition, No. 8, was started in 1921 and is scheduled to be completed in about five years. Even after completion, however, it will continue to be supplemented.

The handbook is an exhaustive encyclopedic compilation, covering data on inorganic chemistry; physical chemistry; physics (including nuclear physics); analytical chemistry; colloidal chemistry; technology; crystallography; optical, electrical, and magnetic qualities of matter; mineralogy; geology; and metallurgy.

The *Gmelin Handbook* now comprises about 58 000 pages of text and figures. A classification scheme is used that facilitates the location of each compound or a combination of elements within the Gmelin series. This scheme is based on an arbitrary numerical sequence of elements—the so-called system numbers; it permits the systematic and comprehensive treatment of all major anionic groups for each cation-forming element in one place. Thus, all major compounds or properties of an element are classified in a volume pertaining to that element.

Like the *New Series of the Landolt-Börnstein Tables*, the *Gmelin Handbook* also accommodates its English-reading users by distributing a special brochure in English describing how its data are organized and classified. Further, since 1957, very detailed English headings and references are printed along the margins of the text. In addition to providing rapid and easy access to specific data, the bilingual headings and references serve as an excellent German-English glossary of terms.

The production of a work of this scope requires a large organization. The Institute's staff consists of about 80 scientists and an equal number of technical assistants

and auxiliary personnel. The staff has at is disposal all the major abstract journals, including those from Russia and China. In addition to these, more than 2 million archive cards are contained in its collection.

The Gmelin Institute maintains close ties with several American organizations, particularly the American Chemical Society; its U.S. office is located in Larchmont, N.Y.

The *Beilstein Handbook* deals solely with organic chemistry, and was first published in 1880. Within the next two decades and with the help of only one or two assistants, Beilstein prepared four volumes having a total of 6800 pages. Today, the *Beilstein Tables* comprise a Hauptwerk (main-work) of 28 volumes and three 28-volume supplements (all of which contain subvolumes). The main-work covers the literature to 1910 while the supplements cover the subsequent period to 1950. Altogether well over 100 000 pages have been published, and additional supplements will be published.

*Ullmann's Technische Chemie*, another of Germany's major technical handbooks, covers almost every aspect of modern chemical technology. The third and latest edition was initiated in 1951. To date, 17 volumes of this edition have been published—the latest in 1966. It will take several more years to complete the work; at present, this edition totals about 14 000 pages.

Besides these well known data compilation activities, Germany has a number of lesser known programs. One is the Documentation of Molecular Spectroscopy (DMS), which is based on the close cooperation of scientists in Great Britain and Germany. The DMS began publishing infrared spectral cards in 1956, and has since covered about 15 000 spectra.[2] The spectral cards are rim punched, slotted cards, which are coded according to various properties. To simplify sorting large numbers of spectral cards, a visual punched-card index was devised. Each index card has 5000 punchable positions. The serial number of each spectral card corresponds to one of the positions on the index card, while each index card corresponds to one of 211 possible properties encoded on the spectral cards. One issue of index cards covers a set of 5000 spectral cards. By combining the index cards of specific properties, the alined holes in the cards indicate the serial numbers of those spectral cards that are coded for that particular combination of properties.

This same system is being used for two "current literature services" provided by DMS—one for infrared, Raman, and microwave literature; the other for nuclear magnetic resonance, electron paramagnetic resonance, and nuclear quadrupole resonance literature. Lists of about 600 pages are published every three months. Small-size visual punched-card indexes are included with the list, but will be replaced later by a large general index. In the future such literature services may be produced for mass spectroscopy and for emission spectroscopy, including atomic absorption and x-ray fluorescence.

A number of large German companies, particularly chemical and electrical companies, have developed their own systems of documenting critical data. One example is the Dornier Aeroplane factory which, with the help of IBM, has developed its own electronic "Dornier System" for storage and retrieval of important data. It uses a computer with a core memory of 16 000 words, and four long-time storage units, having 62 million words. The system was started with 45 chemical elements and their compounds, 25 physical properties and their combinations, and many other necessary data. It covers materials that can be bought commercially and includes the names of the suppliers throughout the world.

Unique to Germany are the DECHEMA material tables, which have the special purpose of compiling data on corrosion. Their 3200 pages provide data on the properties or reactions of 100 typical materials with more than 1000 different chemical substances.

A similar but smaller information system is edited by the Deutsche Kunststoff Institut of the Technical University of Darmstadt. It is managed by Professor Hellwege, editor of the *Landolt-Börnstein Tables*. This punched-card collection of data pertains to synthetic polymers.

### Reaction Kinetics of Neutral Oxygen Species

NSRDS–NBS–20, *Gas Phase Reaction Kinetics of Neutral Oxygen Species*[3] (49 pages; 45 cents), by Harold S. Johnston, is a review and re-analysis of the available chemical rate data for reactions among the neutral oxygen species O, $O_2$, and $O_3$. It is an up-to-date report on the status of the field.

Recommended expressions for rate coefficients (as a function of temperature) are developed for the reactions:

$$O_2 + M \rightarrow O + O + M$$
$$O + O + M \rightarrow O_2 + M$$
$$O_3 + M \rightarrow O + O_2 + M$$
$$O + O_2 + M \rightarrow O_3 + M$$
$$O + O_3 \rightarrow O_2 + O_2$$
$$O + O_2 \rightarrow O + O_2 \text{ (isotopic exchange)},$$

where M is an atom or molecule that serves as a "third body."

The analyses for each case are new. The available material for each reaction has been examined and that material considered still to be valid was used in developing the recommended values. In each case individual data points reported in journal articles are the basis for the analyses. All the data points used are tabulated in the monograph and are shown in figures, together with the recommended values.

Two of the results obtained deserve special mention. Mr. Johnston has shown that the many shock-wave studies of oxygen dissociation have produced data points that are consistent with each other; that is, they are samples of the same population but when they are viewed individually, the studies give widely different values. He has also made independent kinetic analyses for $O_3 + M \rightarrow O_2 + O + M$

*continued*

and $O+O_2 + M \rightarrow O_3 + M$ and has shown that the ratio of these rates is in reasonable agreement with the thermodynamic data. The very slight discrepancy between the kinetic and thermodynamic analyses suggests a possible need for more calorimetric studies on ozone decomposition.

### Reaction Rates for the H-O-N System

Another compilation of interest to chemical kineticists is *Reaction Rate Compilation for the H-O-N System* [4] by Gilbert S. Bahn. This book is a reprinting of material that appeared in three parts in the periodical *Pyrodynamics*, Vol. 5 (1967).

The work is a compilation of rate coefficients for reactions among atoms and simple molecules composed of only the atoms H, O, and N. Almost all of the reactions are elementary, one-step processes. The important species included are H, OH, $H_2O$, $HO_2$, $H_2O_2$, O, $O_2$, $O_3$, N, NH, $NH_3$, $N_2H_4$, and its fragments, HNO, $HNO_2$, $HNO_3$, and the nitrogen oxides.

The compilation is organized by reactions, with separate entries given for the forward and reverse reactions of a system. Under each reaction the material is organized by rate coefficient expression. For each of these values, the reference or references in which they are cited are given, together with remarks. These remarks cover the applicable temperature range, and the experimental method (where applicable); they often trace the values through the secondary references to their source.

Ample auxiliary material is provided to aid the user of the compilation. There is an index of reactions in which the order of reactants is permuted. An author index is provided. References are listed both in lists keyed to the compilation and to the *Pyrodynamics* bibliography system. They are also listed by journal or by report issuer.

The coverage is extensive—it includes both published papers and reports. This compilation has as its goal a comprehensive listing of all available rate data for the reactions covered. Necessarily it includes many secondary references and statements of rates that are not based on experiment. The reader interested in experimental work will still have to sort through the material presented. The remarks indicate a careful examination of the source documents. The extensive mathematical, typographic, and bibliographic errors in the original papers should give casual users of rate data fair warning about the state of the literature. This is an exceptionally useful book for the student of reactions of atoms and light molecules.

### Optical Atomic Spectra

The three volumes of NBS Circular 467, *Atomic Energy Levels*, by C. E. Moore, contain for each spectrum the bibilography that was used in compiling the data. A continuation of these bibliographies with the same format has been published in NBS Special Publication 306, *Bibliography on the Analyses of Optical Atomic Spectra, Section 1*, $^1H$–$^{23}V$ (80 pages; $1), also by C. E. Moore.[2] It covers the literature published after NBS Circular 467 up to the present. The selection of references is restricted to those needed for the preparation of revised tables of atomic energy levels and multiplets.

### CODEN Supplement

*Supplement to CODEN for Periodical Titles*, by J. G. Blumenthal, M. Karaman, and A. Peters, has been published in the ASTM Data Series DS 23A-SI.[5] It is a supplement to the second edition of *CODEN for Periodical Titles*, ASTM DS 23A published in 1966. It adds 22 788 periodical titles and 2099 nonperiodicals to the 39 000 items presented in the second edition.

The CODEN system provides a form of abbreviation of serial titles that is suitable for both manual and machine use. A CODEN symbol[6] consists of a five letter group identifying the series, the first four of which are often a mnemonic for the title. The fifth letter is a bookkeeping addendum. Example: NAFF-A, Natural Food and Farming (Atlanta, Tex.). The serials coded into the system are mainly in the science and technology area. At present, most of the periodicals in the physical sciences, medicine, and engineering are included; coverage in other areas is good.

The CODEN project is a continuing activity of ASTM and is carried out at the Franklin Institute in Philadelphia, Pa. At present the system includes some 75 000 titles and new material is being added at the rate of 2000 per month.

### Neutron Cross Sections and Technology Proceedings

The Second Conference on Neutron Cross Sections and Technology was held in Washington, D.C., on March 4–7, 1968. Papers from this Conference have been published in two volumes as *Neutron Cross Sections and Technology, Proceedings of a Conference*, NBS Special Publication 299 [3] (1341 pp.; $10.50 per set), edited by David T. Goldman. These volumes contain the texts of both the invited and contributed papers of the Conference. Topics include: The need for neutron data in science and technology; standard data and flux measurements; the determination of neutron cross sections by theoretical and experimental techniques; a presentation of recently measured data and their utilization in a variety of applications.

[1] See NSRDS News: Landolt-Bornstein Tables, NBS Tech. News Bull. 51, No. 6, 120–121 (June 1967).

[2] Information on DMS publications may be obtained from Butterworth & Co., 4/5 Bell Yard, Temple Bar, London, W.D.2, England.

[3] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

[4] Published by Gordon and Breach, Science Publishers, New York, N.Y., 1968; price $15.75.

[5] Available from the American Society for Testing and Materials, Philadelphia, Pa., 1968, 469 pages; price $45.

[6] A full explanation of the CODEN System may be found in the article A Review of the ASTM CODEN for Periodical Titles, by Donald P. Hammer, Library Resources & Technical Services 12, No. 3, 359–365 (1968).

# CEMENT PROPERTIES RELATED TO PERFORMANCE

A statistical study[1] relating cement characteristics to compressive strengths has been made at the NBS Institute for Applied Technology. The effects of variables such as cement composition and fineness on the compressive strength of mortars were determined for specimens cured under various conditions and for different periods of time. The tests were conducted during the 15-year period from 1953 to 1968 and analyzed by R. L. Blaine, H. T. Arni, and M. R. DeFore of the Building Research Division.

The study was undertaken to determine the long-range strength development of different cements and the variables associated with the strengths developed with accelerated curing. It was part of a larger program dealing with heat of hydration, sulfate expansion, autoclave expansion, shrinkage and cracking of neat cements, shrinkage of concrete, freeze-thaw durability, absorption, and other variables.

Specifications for portland cements include a combination of physical and chemical limits, all of which have evolved from studies on these materials. One important property of hydraulic cements, however, which is not usually considered adequately in the specifications, is that their strength may, under suitable conditions, increase for many years after mixing, placing, and initial curing of the concrete. Test requirements for strength and potential strength at later ages are usually based on tests at 3 and 7 days, together with some knowledge of the chemical composition of the cements. This is frequently inadequate because concrete strengths at early ages do not always provide reliable predictions of their strengths at later ages.

Furthermore, at one time nearly all concrete was placed on the job site. At present, however, there is an increasing amount of precasting of concrete structural elements at sites removed from the job, and to make the most efficient use of the casting area, among other reasons, accelerated curing is used. There are, at present, no nationally recognized specifications for cements for such use, although it is recognized that some cements are better than others.

To bridge this information gap, NBS tested 199 portland cements from different areas of the country. Complete chemical analyses, including spectrochemical determinations for trace elements, were made on the cements.

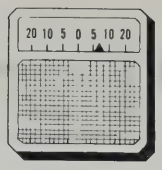
The compressive strengths of the test mortars were determined at 1, 3, 7, and 28 days, and 1, 5, and 10 years after storage in water. Tests were also made of compressive strengths after curing in moist air and in laboratory air for one year. In addition, a second series of tests was made in which mortar specimens were cured with steam at pressures of 1 and 10 atmospheres after 5 and 24 hours of initial curing.

The results of the tests were analyzed with the aid of a digital computer and the use of a least-squares method to determine and evaluate the different variables. These variables were chemical composition (including trace elements), as well as fineness and other properties of the cements significantly associated with the strength, the strength gain, and the strength-gain ratios of the different cements.

The analysis of the test results indicated (1) that much of the broad range of compressive-strength values under both normal and accelerated curing, could be explained by the differences in chemical composition of the cements. (2) The cement composition resulting in the greatest compressive strength with accelerated curing may differ from the optimum composition for normal curing. (3) A higher percentage of tricalcium aluminate was associated with higher strengths at the early test ages, but with lower strengths at 1, 5, and 10 years. (4) A higher quantity of potash was associated with higher strengths at the very early ages and a higher percentage of soda with lower strengths at the later ages. (5) The effects of dicalcium silicate and tricalcium silicate were apparently different at different test ages and curing conditions. (6) The fineness of the cement as well as the air-entraining characteristics were also found to be important variables.

With the better knowledge and understanding gained in this study it is now possible to predict more accurately the potential concrete strength development at later ages and the effects of accelerated curing.

[1] For complete details, see R. L. Blaine, H. T. Arni, and M. R. DeFore, Interrelations Between Cement and Concrete Properties, Part 3, NBS Bldg. Sci. Series–8 (Apr. 1968), 55 cents. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.



# STANDARDS AND CALIBRATION

## A SIMPLE, ECONOMICAL 1-MHz INDUCTIVE VOLTAGE DIVIDER

### High Accuracy with Ratios of $2^n$:1 or 6n dB

A binary inductive voltage divider is a device that divides its input voltage into two equal parts and is a convenient means of providing definite, known lesser voltages. Such devices are in considerable demand by the electronics industry and electronics standards laboratories. Binary dividers are simple yet accurate, inexpensive, and easy to construct. They have simple "exact" circuits, so that combinations of binary dividers are relatively easy to analyze.

Recently, Bureau scientists developed a decade voltage divider usable at a frequency of 100 kHz.[1] Now, C. A. Hoer and W. L. Smith, of the NBS Radio Standards Engineering Division at Boulder, Colo., have developed an accurate binary voltage divider with ratios of $2^n$:1 or 6n dB by cascading n binary dividers designed to operate at 1 MHz.[2] A theoretical and experimental study yielded expressions for each error encountered. The individual error equations were then used to give an expression for the ratio error.

The internal loading error, caused by the small but significant voltage drop across the short-circuit output impedance, can be either compensated for, or eliminated. Most of the internal loading error can be eliminated by an adjustable admittance connected across the top half of each section. This admittance is adjusted to be equal to the total admittance across the bottom half of the section.

Hoer and Smith constructed and tested an experimental seven-section voltage divider with a total of approximately 42 dB in seven 6-dB steps. (The divider gives voltage ratios of 1/2 to $1/(2^7)$.) The seven-unit assembly, designed to operate at 1 MHz, has an estimated uncertainty of $\pm 0.007$ percent per section.

The individual binary dividers were constructed with cables made by folding a length of No. 24 copper thermocouple wire in half and twisting the pair fairly tightly with a hand drill. After winding the cable on a bobbin, the bobbin was inserted in low-loss cup cores having an effective permeability of about 30. The number of turns of twisted cable on the bobbin was chosen so that the self resonant frequency was slightly above 1 MHz. A resistor (100-kΩ variable cermet trimmer) and a capacitor (10-pF variable piston trimmer) were included in the circuit of each divider to obtain equal, purely resistive loads across the top and bottom of the divider.

External loading errors are compensated through the use of a voltage comparator developed by C. Hoer and W. Smith, which is similar to the current comparator developed by R. A. Lawton and C. M. Allred.[3] The voltage comparator was used to compare the output of a binary voltage divider with the output of a precision waveguide below-cutoff piston attenuator at 1 MHz using the parallel direct-substitution method. Through use of the voltage comparator, the binary voltage divider and the precision attenuator were terminated in the impedance for which they were designed. The results of this comparison agreed within the uncertainty of the attenuator (0.003 dB/10 dB) and the divider (0.001 dB/10 dB).

According to Hoer and Smith, binary voltage dividers of this type could be very accurate at frequencies well above 1 MHz. Experiments at NBS show that at 30 MHz, the divider error can be as small as 1 part per ten thousand—an indication that binary voltage dividers should be useful at even higher frequencies.

## DETERMINING SUBSTITUTION ERROR OF WOLLASTON-WIRE BOLOMETERS

An experimental and theoretical verification of the magnitude of one of the most important errors in bolometric power measurements, the rf-dc substitution error of a bolometer with a Wollaston-wire (fine platinum wire) element, has been achieved at the NBS Institute for Basic Standards, Boulder, Colo. A mathematical analysis for determining the value of the substitution error has been developed by Stephen Jarvis, Jr., and John W. Adams of NBS. It is a solution to a nonlinear heat flow differential equation. The analysis reflects all significant nonlinearities in the heat flow and includes all appreciable heat transfer mechanisms simultaneously.

In the measurement of microwave and millimeter-wave power (rf power) by substitution techniques, substitution error is of great concern. A common measurement technique is to replace a known amount of dc power with an unknown amount of rf power in a bolometer. Unfortunately, the different current distributions generate different temperature fields which give the bolometer elements slightly different values of total resistance for equal

amounts of power. For balanced-bridge methods the resistance is maintained constant, which causes some nonequivalence of power. In this case, substitution error is defined [4] as

$$E=\frac{W_{sub}-W_{rf}}{W_{rf}}.$$

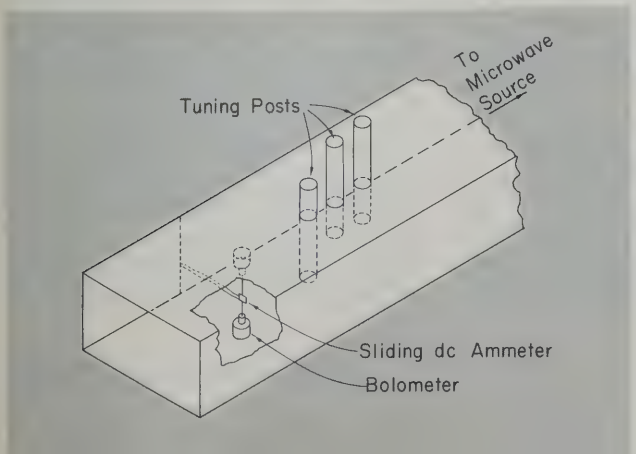
Although a bolometer can be used to measure relative powers without calibration, it must be calibrated to measure absolute power. An accurate method of calibration is by the use of a calorimeter in which the ratio of substituted dc power to the net rf power flowing across an arbitrary plane into the bolometer is measured.[5] This quantity is called the effective efficiency. Effective efficiency in the 7 to 40 GHz frequency range can be determined by precision calorimeters, which serve as reference standards. Efficiency in the 4 to 7 GHz frequency range can be determined using waveguide impedance systems.[6] The effective efficiency is related to efficiency by

$$N_e=N\ (1+E)$$

where E is the substitution error. While the magnitude of the substitution error is relatively small in the 4 to 7 GHz frequency range, a knowledge of its magnitude permits greater confidence in a calibration. As frequency increases, the magnitude of the substitution error becomes progressively greater. At frequencies above 40 GHz, where calorimetric standards are not yet available, substitution error becomes particularly significant. Here the amount of the error must be known so that effective efficiencies may be calculated.

The analysis by Jarvis and Adams of the substitution error required a knowledge of the current distribution in a Wollaston-wire bolometer element. A scaled-up (approximately 20 times with the respect to X-band) bolometer mount was used with a 700-MHz rf signal to measure this distribution directly. A current probe, consisting of a tiny coil and rectifier, was moved along the wire (which simulated the bolometer element) to monitor the current distribution. The dc output from the rectifier was conducted to meters outside the waveguide on high-resistance wire. The use of the high-resistance wire substantially reduces the relative perturbation of the rf field in the waveguide. Measured values of rf current distributed axially along the wire revealed a maximum near the middle of the wire while the remainder, in general, described a sinusoidal shape. The amount of curvature was frequency dependent. The current magnitude varied greatly but the distribution varied only slightly as the position (with respect to the bolometer) of the shorting end-plate was varied or as the adjustment of the tuning screws was changed. The location of the current maximum changed when the shorting end-plate was tilted even a few degrees from perpendicular. Variations in the shape and the size of the wire supporting structure caused variations in the current amplitude profile but these seemed related to changes in the wire length.

*Schematic of scaled-up bolometer mount used in measuring current distribution in Wollaston-wire bolometers.*




The results of this NBS research will benefit the Nation's industry and commerce by allowing bolometer mount efficiency calibrations with greater confidence in the 4 to 7 GHz frequency range. The use of the impedance technique coupled with the results of this analysis may also prove to be a satisfactory calibration method at frequencies in the millimeter-wave (above 40 GHz) region.

## STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in $10^{10}$ due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on January 1, 1969.*

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on January 1, 1969.*

[1] This work was done by D. N. Homan and T. L. Zapf. See, Improved high-frequency voltage divider, NBS Tech. News Bull., **52**, No. 10 (Oct. 1968).
[3] Hoer, C. A., and Smith, W. L., A 1-MHz binary inductive voltage divider with ratios of $2^n$:1 or 6n dB, IEEE Trans. Instr. Meas. (in press).
[3] Allred, C. M., and Lawton, R. A., A precision current comparator, IEEE Trans. Instr. Meas. **IM-16**, No. 2, 142–145 (June 1967).
[4] Carlin, H. J., and Sucher, M., Accuracy of bolometric power measurements, Proc. IRE **40**, 1042–1048 (1952).
[5] Engen, G. F., A refined X-band microwave microcalorimeter, J. Res. NBS **63C** (Engr. and Instr.), No. 1, 77–82 (1959).
[6] Engen, G. F., A bolometer mount efficiency measurement technique, J. Res. NBS **65C** (Engr. and Instr.), No. 2, 113–124 (1961).

# SOUND LABORATORY BUILDING

## ADDED TO NBS COMPLEX

*The special design and construction of the reverberation chamber has a shell-within-shell design and massive 4000-pound inner doors.*

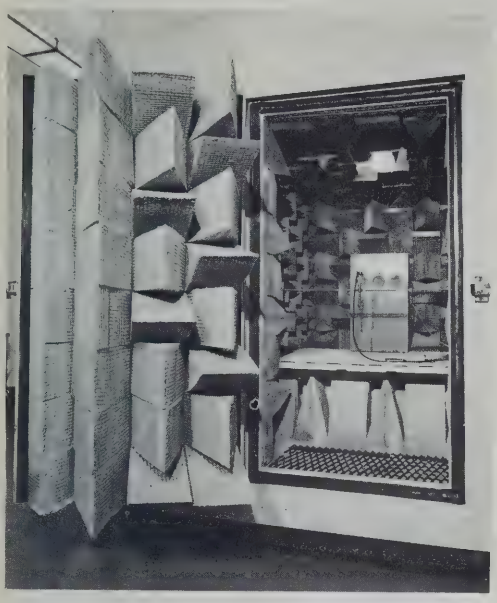
One of the more specialized features of the new NBS laboratory complex in Gaithersburg, Md., is the recently completed Sound Laboratory building. A single-story structure of unique, highly specialized construction and acoustical design, the laboratory was built specifically for basic research in the fields of ultrasonic, infrasonic, physical, and audio acoustics and vibration.

Much of the work carried out in the building will be directed toward: (1) The development and standardization of calibration procedures for microphones, audiometers, earphones, vibration-measuring systems, bone-vibrators, artificial ears, and hearing aids; (2) the study of the properties and characteristics of reverberant sound fields; (3) the determination of speech intelligibility and the loudness or human response to noise; (4) the study of the velocity of sound, thermodynamic behavior, and other properties of matter by using physical-acoustic, cavitation, and ionizing radiation techniques; (5) the development of new or improved methods for the measurement of the acoustical power radiated by various types of noise sources and for measurements of the absorption and transmission of sound in building materials and structures; (6) the development of methods for generating and measuring vibratory motion having amplitudes from $10^{-8}$ to $10^{-1}$ meter and frequencies up to 100 kHz; (7) the development of methods for generating, measuring, and analyzing motions suitable for calibrating shock-measuring pickups; and (8) the development of new and improved transfer standards to permit the calibration of vibration pickups at field installations. These research programs will be conducted by staff members of both the Sound Section and the Vibration Measurements Section of the Mechanics Division, who are now quartered in the new building.

In addition to these programs an expanded program in applied architectural acoustics, which will require modern though somewhat different laboratory and test facilities, is currently being developed by the Building Research Division of the NBS Institute for Applied Technology.

### Acoustical Design and Construction

The primary requisite of an ideal Sound Laboratory building is that it have a very low internal ambient noise level under normal operational conditions. This means that the intrusion of noise from outdoor sources must be negligible and that noise generated within the building, either by experimental or any other operational activity, must be controlled, reduced, or confined to prevent undue interference with research or experimental work



Left: *Courtney Burroughs sets up an experiment for measuring the sound absorption properties of a rug in the reverberation chamber, which is one of the main features of the new building.* Right: *Sound reflection from the walls is suppressed by an arrangement of porous wedges in this small "anechoic chamber." Useful at frequencies greater than 200 Hz, this chamber was set up for a frequency-response measurement on a loudspeaker, and is particularly well adapted to work on hearing aids.*

being conducted in other areas of the building.

Such acoustical performance requirements have been attained, albeit with some difficulty, in the new NBS Sound Laboratory building even though the experimental work conducted within will cover an extremely wide dynamic range of sound-pressure levels. In some laboratory spaces, for example, levels as high as 150 decibels, roughly approaching those radiated by jet engines, may be generated. In other laboratory areas audiometric investigations will involve measurements of sound-pressure levels about 30 decibels below the threshold of hearing.

To accommodate experimental work covering this dynamic range, without interference from or with other laboratory activity, sophisticated sound-insulating, noise control, and vibration-isolating techniques were mandatory in the design and construction of the building.

First and foremost, the intrusion of outdoor noise was minimized by using 6-inch-thick, dense, solid-core concrete blocks faced with bricks, reinforced concrete slabs, and double-pane windows in the construction of the exterior faces of the building, along which the office modules are located. The laboratory modules, with noise-sensitive areas widely separated from intense-noise areas, are located in the central core of the building and surrounded by an acoustically treated corridor, which serves as an acoustical barrier or buffer zone. The installation of acoustical ceilings throughout the building further reduced the low ambient noise level within. In both laboratory and office areas, the interior partition walls were constructed of the same solid-core type of concrete blocks, and thick sound-insulating wooden doors were installed in these areas.

Some laboratory spaces requiring a higher degree of sound insulation have double walls of block construction that are separated by an airspace, and utilize floating floors, which are structurally isolated from the building structure.

Two of the main features of the Sound Laboratory building are the anechoic and the reverberation chambers. These are both huge, massive, shell-within-shell type structures, whose inner shells are floating on helical-coil steel springs. The walls of the exterior shells, which are 22 inches thick and constructed of reinforced high-density concrete and brick facing, enclose a 3-foot airspace envelope surrounding the 18-inch-thick concrete inner shells.

The anechoic chamber, which is the larger of the two, has a bare inner-shell volume of approximately 52 000 cubic feet, but this will be reduced to about 16 000 cubic feet upon the full-coverage installation of 6-foot-long fiberglass wedges on all six interior chamber surfaces. The fiberglass installation will provide an "acoustically-dead" environment that will be at least 99 percent sound absorbent in the audiofrequency range above 50 cycles per second.

In contrast, the reverberation chamber, which has a volume of approximately 15 000 cubic feet, will be about 95 percent sound reflecting over most of the audiofrequency range. The large volume of enclosed air possesses an appreciable amount of sound absorptivity that limits the reverberation response of the room at higher frequencies. But low-frequency sound signals introduced into the chamber will echo and re-echo for periods as long as 25 to 30 seconds.

The airborne, impact, and structure-borne noise generated in the electromechanical room and various test chambers is confined in such areas, or its transmission is controlled and reduced to negligible levels to prevent

*continued on page 281*

# CONFERENCE & PUBLICATION Briefs

2336

## HYDROXYAPATITE SYMPOSIUM

In their chemical diversity, in their biological importance, and in their various commercial applications, the apatites comprise a remarkable group of inorganic compounds. Most prominent of the apatites are hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$, and its structurally related compounds. As the principal inorganic component of tooth and bone, hydroxyapatite is of great dental and medical interest. It, and its related compounds, are of importance in such diverse fields as fertilizers and agriculture, mineralogy, oceanography, water purification, fluorescent lighting, sugar purification, catalysis, chromotography, and, most recently, laser technology.

The properties of these compounds were examined, for the first time in such depth, at the Symposium on the Structural Properties of Hydroxyapatite and Related Compounds. Held September 12–14, 1968, at the Bureau in Gaithersburg, Md., the Symposium was cosponsored by NBS and the Biological Sciences Division of the Office of Naval Research. Co-chairmen for the Symposium were Walter E. Brown, Director, American Dental Association Research Division at the Bureau, and R. A. Young, Professor of Physics, Georgia Institute of Technology.

The Symposium opened with a joint welcome from I. C. Schoonover, Deputy Director, NBS, and J. P. Pollard, Director of the Biological Sciences Division, ONR.

The technical program was then introduced by a pair of papers on the crystal structures and chemical compositions of apatites. R. A. Young, K. Sudarsanan, and P. E. Mackie (Georgia Institute of Technology) presented the results of several x-ray structural analyses of hydroxyapatite and its fluoride- and chloride-containing analogs. As recounted by Dr. Young, the disorder in the positions of the $OH^-$ ions of hydroxyapatite is of basic importance to many of its physical and biological properties. The second paper, by H. Wondratschek (Technische Hochschule, Karlsruhe), described the great variability in chemical compositions, types of vacancies and superstructures, and modifications in crystal symmetry among the apatites.

A series of six papers then described the application of various physical methods to the study of apatites. A. Bienenstock and A. Sonner (Stanford University) developed equations to distinguish the diffuse x-ray scattering produced by the "ordered" and "disordered" $OH^-$ column models. They also compared observed and calculated x-ray scattering for postulated structures of an "amorphous" calcium phosphate, a precursor phase in the precipitation of hydroxyapatite from solution. Discussing infrared spectra, B. O. Fowler (National Institute of Dental Research, National Institutes of Health) described a new assignment of peaks in the spectrum of hydroxyapatite.

The polarized infrared and Raman results reported by L. C. Kravitz and G. D. Mahan (General Electric Research and Development Center) yielded more details for understanding the vibrations of fluorapatite. With this technique it was possible to compute the effects of interionic couplings and the anisotropy of the vibrations in the infrared. W. van der Lugt and W. J. Caspers (University of Groningen, Netherlands) gave an introduction to two methods that are still in a fairly early stage of application to the study of apatites: nuclear magnetic resonance and electron paramagnetic resonance. From NMR and EPR research, they presented information about types of protons, lattice defects, and impurities in apatites. In a paper on optical microscopy James R. Lehr (Tennessee Valley Authority) emphasized the polarizing microscope as one of the most useful, and most neglected, adjuncts in the study of the physical properties of crystalline compounds. He stressed the importance of optical microscopy for detecting contamination in apatitic preparations used in chemical and physical investigations. The final paper of the session dealt with the electron microscope and the difficulties of interpreting micrographs. R. D. Heidenreich (Bell Telephone Laboratories, Inc.) and E. Zeitler (Armed Forces Institute of Pathology) described theoretical and practical limitations in various modes of the microscope's operation.

A paper by D. B. Scott, J. W. Simmelink, J. R. Swancar, and T. J. Smith (Case-Western Reserve University) in a later session illustrated the application of this instrument to mineralization processes in tooth and bone.

The following day's topic, relating to the roles of carbonate in hydroxyapatite, stimulated the most discussion of the Symposium. Three papers by J. C. Elliott (The London Hospital Medical College), by D. Carlström (Karolinska Institutet, Stockholm), and by G. H. McClellan (Tennessee Valley Authority) reported the progress that has been made in this area. It was related that

carbonate ions appear to occupy at least two sites in the apatite lattice. As indicated by their effects on the unit-cell dimensions and the infrared spectra, one site is occupied when the material is prepared at high temperatures, and the other site is used when the apatite is formed in aqueous environments.

The apparent variable stoichiometry of hydroxyapatite, even when free of carbonate and other foreign ions, has been a problem of concern for many decades. Over twenty proposals to account for this variability were reviewed by W. E. Brown (NBS). From these proposals it was concluded that the most common cause for the variation was the presence of other, more acid, calcium phosphates.

A self-consistent set of thermodynamic values for the calcium phosphates was presented by E. C. Moreno (NBS). This set was based on the conclusion that the measured heats of dissolution are the least reliable of the data derived from the calorimetric measurements, and that it is necessary to employ data derived from solubility measurements.

A major problem limiting progress in the study of apatites is difficulty in obtaining suitable crystals. R. Roy and D. M. Roy (Pennsylvania State University) stated that fluorapatite is now successfully grown from the melt, and prospects are promising for the growth of hydroxyapatite.

Considerable progress has been made in the study of electronic properties of defects of fluorapatite and chlorapatite because of their importance as phosphors in fluorescent lamps. J. S. Prener and W. W. Piper (General Electric Research and Development Center) reviewed optical and electron paramagnetic resonance spectroscopy studies of such defects.

Two other papers were presented on structure-related properties. Electrical and transport properties in apatites are of possible great importance to biological properties, but their experimental study was initiated only recently. J. Arends, B. S. H. Royce, R. Smoluchowski, and D. O. Welch (Princeton University) used structural properties and experiences with other systems to derive estimates of the dielectric and conductivity properties.

The obvious importance of the stress-strain properties of tooth and bone (hard tissue) led to extensive study of their mechanical properties; only limited measurements have been made either on the separate components of hard tissue, or on their composites under high strain rates. J. L. Katz and R. S. Gilmore (Rensselaer Polytechnic Institute) spoke of their elastic measurements on various apatites as a function of pressure (up to 50 kbar); measurements were also made on mixtures of hydroxyapatite and sodium chloride, which provided a model composite system.

The final two papers were devoted to questions relating to biological problems. B. Dickens (NBS) stressed the variety of other compounds that can provide useful information about the biologically important calcium phosphates. Dr. Dickens also discussed the structural basis for the relationship between octacalcium phosphate and hydroxyapatite, the possible role of tetracalcium phosphate in the chemistry of apatites, and the relevance of a host of carbonates and other phosphates to the structures and properties of the salts known to occur in mineralized tissues.

Concluding the Symposium, A. S. Posner (Cornell University Medical College) spoke of the many problems in calcium phosphate structure research that require further elucidation: factors that control particle size and shape in tooth and bone; the piezoelectric properties of bone as they relate to disordered structure in hydroxyapatite; the effects of fluoride and how they relate to caries, osteoporosis, and Paget's disease; and the roles of surface and composition as they may relate to physiological processes such as formation of biopolymers.

The Symposium helped to resolve many of the basic problems relating to the properties of apatites. It is felt that future research in this area will achieve a better balance of emphasis as a result of the enhanced perspectives to which it contributed. The proceedings will be published in the form of a text in the coming year.

## SAMA AND NBS HOLD MEASUREMENT TECHNOLOGY CONFERENCE

The Scientific Apparatus Makers Association and the National Bureau of Standards held a two-day Conference on Measurement Technology at the NBS facilities at Gaithersburg, Md., on September 17–18, 1968. The purpose of the Conference was to better acquaint the members of SAMA with the facilities, resources, and services of the Bureau. The program was arranged and coordinated by George E. Lawrence, Executive Vice President of SAMA, and George S. Gordon, Chief of the NBS Office of Industrial Services.

SAMA is a trade association of manufacturers whose primary activity is to provide scientific apparatus to the technical and scientific communities. The Association, therefore, is vitally interested in the activities of the Nation's central measurement laboratory.

The attendees were welcomed to the Conference by Nathan Cohn, SAMA President Pro Tempore and Executive Vice President of Leeds and Northrop Company, who explained the general purposes and organization of SAMA.

*Herbert J. Mossien, SAMA President, addresses Conference attendees.*

*continued*

A. V. Astin, Director of NBS, also presented a welcoming address in which he outlined the Bureau's responsibilities and the assistance that it renders to industry. Senior members of the Bureau staff then reviewed in more detail the services of the Bureau to industry. Among the topics covered were calibrations and measurements, standard reference materials, technological measurements and standards, and international standards.

The keynote address was presented by John F. Kincaid, Assistant Secretary of Commerce for Science and Technology. Speaking on "Science, Technology, and Everyman," Dr. Kincaid pointed out that man is today at the mercy of his own technology. This being the case, he said, we must direct our attention toward a zero-defects goal. He went on to ask, "Can man learn to live in a world in which he is weak and inadequate in comparison to the technological entities he has created?" He can, said Dr. Kincaid, but first, "we must raise man's understanding of science and technology."

Following Dr. Kincaid's address, the Conference was divided into a number of concurrent seminars. In these seminars NBS scientists discussed Bureau programs in such areas as polymers, analytical chemistry, electrical measurements, and optical length measurements. Other concurrent seminars followed in which the Bureau's capabilities in the fields of electronics, heat, physical chemistry, and inorganic materials were considered.

During the morning of the second day, plenary sessions were held in which NBS staff members gave talks on the National Measurement System, the International System of Units, technical information dissemination, computer technology, and the National Conference of Standards Laboratories.

H. J. Mossien, SAMA President and Vice President of Bausch & Lomb, commented on the close cooperation between SAMA and NBS and went on to say: "We in SAMA pledge ourselves to support an effort to make the National Bureau of Standards an international symbol of U.S. leadership in science and technology."

Following the luncheon, G. S. Gordon, Chief, NBS Office of Industrial Services, presented a talk on the Bureau's Research Associate Program. Dr. Gordon pointed out that the Program is a cooperative effort in research between NBS and industry. It allows scientists and engineers under sponsorship of individual companies to perform research using the resources of the Bureau. The results of such research are then published and become part of the public domain.

The remainder of the Conference was devoted to a tour of the NBS facilities. The guests were shown the Bureau's new 10-megawatt research reactor, which is used to generate intense beams of thermal and subthermal neutrons. Also included in the tour were radiation facilities for the calibration of x-ray machines, production of neutrons, calibration of neutron sources, and development and processing of standards of radioactivity.

Among the many other stops on the tour were a field emission microscope, x-ray diffraction equipment, a line-standard interferometer for calibration of length scales, nuclear-magnetic-resonance and Mössbauer spectrometers, a high-resolution electron impact spectrograph, the Nation's standard of voltage, and standards and calibration apparatus for the precise measurement of forces of up to 12 million pounds.

## 1968 STANDARDS LABORATORY CONFERENCE

The fourth biennial Standards Laboratory Conference was held August 26 to 29 at the NBS laboratories in Boulder, Colo., under the sponsorship of the National Conference of Standards Laboratories (NCSL). The Conference opened with a challenge to the delegates and the new Board of Directors by NCSL Chairman Charles E. White. He challenged them to chart a course that would accommodate the new growth expected in the organization and that would involve the NCSL in a larger national role as a major coordinator of consistent measurement standards. Such standards are used by research laboratories and more than 2000 standards laboratories in industry, universities, and Government agencies in the United States and in many foreign countries.

Expanding on the theme of the Conference, "Making Valuable Measurements," Chairman White emphasized that one of the goals of NCSL is to encourage industry's top management to re-evaluate its attitude toward the importance of measurement activity because of its impact upon the quality of products and goods.

Keynote speaker A. V. Astin, Director of the National Bureau of Standards, told the delegates that the NCSL is an indispensable link between the Bureau and the technological public which it serves. "The NCSL," he said, ". . . is aimed essentially at adding to the reliability and extending confidence limits . . . in the measured values of goods and services that enter into American industry. . . ." He emphasized that the heart of the Conference theme was the association of accuracy and reliability with measured values, and that measurement activities aimed at achieving more effective interchange of information, goods, and services related directly to the work of the Conference. He said that NBS is very much concerned with trying to evolve techniques for measuring the benefit of measurement processes, and particularly with efforts to achieve increased accuracy as a means of improving the reliability of important components and systems. However, he pointed out that it is extremely difficult, if not impossible, to assign specific dollar values to the act of measurement. "The value arises from the value of the objective for which the measurement may be an indispensable ingredient. But it is not fair to use the total value of that objective as the value of the measurement activity itself," he said.

Dr. Astin reminded his listeners that there have been

*Harvey W. Lance (right), of NBS Boulder, receives congratulations on his election as Chairman of NCSL from outgoing Chairman Charles E. White.*

phenomenal advances in statistical techniques that help us to evaluate and sort out random errors in the measurement process; that there must be a better understanding of the interaction between the object being measured and the measurement process if we are to reduce systematic errors in the measurement process; that we must define more precisely what it is that we want to measure; and that we must understand better the properties and limiting characteristics of the object being measured.

The second morning's session, under the chairmanship of J. L. Hayes, U.S. Navy Metrology Engineering Center, Pomona, Calif., opened with reports on Department of Defense and NBS activities by representatives from these agencies; each was covered by three speakers. A number of professional and trade organizations maintain close liaison with NCSL and have appointed official delegates to NCSL. These delegates or their representatives presented summary reports from the Institute of Electrical and Electronics Engineers; Instrument Society of America; Precision Measurement Association; American Ordnance Association; and Aerospace Industries Association. In the afternoon, emphasis was on the value of compatible international measurements; nine foreign papers from India, England, Australia, Ireland, Sweden, and Canada were presented as well as one paper from the U.S.

Wednesday morning was devoted to NCSL Committee Reports under the chairmanship of W. L. Vandal, McDonnell-Douglas Corp., St. Louis, Mo. Between biennial conferences the main work of NCSL is accomplished by committees made up of delegates from member organizations. Committee reports were given on: Information, Recommended Practices, Statistical Procedures, Calibration Procedures, Measurement Agreement Comparisons, Personnel Development, and Workload Control.

From the framework of the earlier sessions came support upon which the Wednesday luncheon speaker, John L. Sloop, built his theme. Mr. Sloop, NASA's Assistant Associate Administrator of Advanced Research and Technology, talked on "Measurements for Society." He pointed out the importance of considering the social impact (economic, legal, moral) in planning scientific and technological programs. The difficulty, according to Mr. Sloop, is that no scale or measurement technique has been developed. "What yardstick can we apply to measure their [science and technology] importance? How can we assess their impact on social and economic progress? How can we determine how much of our national resources should be devoted to science and technology?"

The business meeting and election of officers for 1969–70 took place at the Delegate's Assembly, midpoint of the Conference on Wednesday afternoon. Harvey W. Lance, Assistant Chief of Program Development and Evaluation, NBS Boulder, was elected Chairman for 1969–70.

Elected Vice Chairmen for 2 years were Richard B. Ernst (Autonetics Division of North American Rockwell Corp., Anaheim, Calif.) and Jerry L. Hayes (Navy Metrology Engineering Center, Pomona, Calif.); for 1 year, James F. Hadley (Bendix Corp., Kansas City, Mo.). E. J. Arsenault (General Electric Re-entry Systems, Philadelphia, Pa.) will fill out the remaining year of his 2-year term as a vice chairman; he also served as Coordinator for this year's Conference. Paul H. Hunter (Western Electric Co., Winston-Salem, N.C.) was elected Secretary. Don I. Hervig (U.S. Army Sentinel System, Huntsville, Ala.) continues in his 2-year term as Treasurer. Sponsor's Delegate is Ernest Ambler, Director of the NBS Institute for Basic Standards.

Five delegates of member organizations were also elected to the Board of Directors. They are: M. T. Angelo (Lockheed-California Co., Burbank, Calif.), H. S. Ingraham, Jr. (RCA, Camden, N.J.), O. L. Linebrink (Battelle Memorial Institute, Columbus, Ohio), W. H. McPhee (Instrumentation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.), and A. J. Woodington (General Dynamics/Convair, San Diego, Calif.).

The last day's morning session was devoted to highlights of laboratory management practices, including the need for and practical value of measurement comparisons, and the control of instrumentation and pertinent data. In the session on the "Value of Measurement Comparison Agreement," under the chairmanship of H. S. Ingraham, conferees heard four papers, including one from England. In the session on "Management of Equipment and Data," under the chairmanship of J. C. Shackelford, they heard seven papers. The closing afternoon session on "Management of Valuable Measurements," chaired by A. J. Woodington, had five papers.

In summarizing and evaluating the Conference, Harvey Lance, as newly elected NCSL Chairman for 1969–70, reflected the view expressed by C. E. White and guest speaker J. L. Sloop: "Advances in civilization and culture are

*continued*

preceded by bold engineering concepts. Engineers have a voice in policies and programs, but first as citizens and only second as technologists. Engineers will be required more and more to test their proposals, not only against the standards of science and technology, but also against the standards of social science."

Mr. Lance concluded, "The Conference revealed growing evidence of more effective cooperation among interested people in Government and industry and the broadening interest of measurement people in social and economic problems. I look forward to a 1970 Standards Laboratory Conference in which important results of these new trends will be reported."

## NICKEL AND ITS ALLOYS

*Nickel and Its Alloys* reviews the available information on the history, production, properties, and uses of high-purity and commercial forms of nickel, and on the properties and applications of its important alloys, both ferrous and nonferrous. Prepared by Samuel J. Rosenberg, NBS Monograph 106 [1] (156 pages; $1.25) revises and updates the data published in 1958 as NBS Circular 592.

The monograph covers the physical, chemical, and mechanical properties of nickel as well as the effect of minor constituents on these properties. The technology, metallography, and uses of nickel are also reviewed.

A treatment of the nonferrous alloys includes a discussion of high-nickel alloys (such as Ni-Cr and Ni-Cr-Fe), low-nickel alloys (Cu-Ni and Cu-Ni-Zn), and miscellaneous alloys. A final section includes a review of ferrous alloys (wrought steels, cast steels and irons, stainless steels, thermal expansion and constant modulus alloys, and magnetic alloys).

## CEMENT AND CONCRETE PROPERTIES

NBS Building Science Series 8 [1] (98 pages; 55 cents), by R. L. Blaine, H. T. Arni, and M. R. DeFore, reports two studies of the interrelations between cement and concrete properties—one dealing with the compressive strength of test mortars, the other with the compressive strength of steam-cured portland cement mortars.

The first portion reports a study of the relationship between cement characteristics and compressive strengths of 1:2.75 mortars of standard consistency at ages from 24 hours to 10 years. Tests were made with 199 cements of different types, the results of which were studied by fitting multivariable regression equations with the aid of a digital computer. The first section includes a study of the effects of the trace elements as well as other components among the variables associated with compressive strength values of mortar cubes at the different ages.

The second portion reports a study of the relationships between the chemical and physical characteristics of 161 portland cements and the compressive strengths of 2-inch mortar cubes made from those cements after both low- and high-pressure steam curing, as well as moist-air curing. The study was carried out by computing multivariable regression equations with the aid of a digital computer, and determining which of the independent variables appeared to have a significant relationship to the compressive-strength values.

## SCHEDULED NBS-SPONSORED CONFERENCES

*Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. For further information, address the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.*

**Symposium on Ion-Selective Electrodes.** Jan. 30–31. Contact: R. A. Durst (NBS Analytical Chemistry Division).

**1969 Particle Accelerator Conference.** Mar. 5–7. Cosponsors: American Physical Society, Institute of Electrical and Electronics Engineers (NSG), National Science Foundation, U.S. Atomic Energy Commission. Contact: E. H. Eisenhower (NBS Center for Radiation Research). To be held at the Shoreham Hotel, Washington, D.C.

**Thermodynamics of Bulk Polymers Symposium.** Mar. 10–11. Contact: A. B. Bestul (NBS Polymers Division).

**Fundamental Aspects of Dislocation Theory.** Apr. 21–25. Contact: J. Simmons (NBS Metallurgy Division).

**NRCA–NBS Joint Symposium on Roofing.** Apr. 29–30, Cosponsor: National Roofing Contractors Association. Contact: T. H. Boone (NBS Building Research Division).

**10th Symposium on Electron, Ion, and Laser Beam Technology.** May 21–24. Cosponsors: University of Maryland, Institute for Electrical and Electronics Engineers (GED), American Vacuum Society. Contact: L. Marton (NBS).

**NBS Measurement Seminars and Workshops 1968–1969.** Two- to five-day courses on measurement and calibration problems. Attendance limited. See October *Technical News Bulletin* for detailed information.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

## SHELTER *continued*

novations incorporated into this system did not fit neatly into conventional building practices and codes. Therefore, testing structural safety was necessary and this subject was covered by E. O. Pfrang of NBS in his talk, "Performance Testing of a Low-Cost Housing System." Dr. Pfrang said that performance testing can be used as a means of evaluating new building systems proposed for use in low-cost housing projects. The results obtained on the Phoenix Project were instrumental in gaining acceptance of that system. He went on to say that many of the systems that are presently being proposed for construction in the United States are highly innovative and involve significant departures from existing building codes. The adequacy of these systems cannot readily be ascertained by a comparison with existing building codes. As a result the only means available for determining their suitability is through full-scale performance testing.

The concluding technical session, *Trends and Opportunities*, focused on developments involving design and construction of entire communities. G. D. Wright, Jr., of Bernard Johnson Engineers, Inc., in a talk entitled "New Town Planning" explained briefly the concept of the new town and specifically dealt with the engineering aspects involved in making a new town (in this case, Columbia, Md.) a viable reality.

"The National IN-CITIES Experimental Low Cost Housing Research and Development Project" was the topic of a talk by P. D. Bush, Kaiser Engineers. He described Phase II of the National "In-Cities" experimental low-cost housing research and development project. This project is part of HUD's program to determine how, under what conditions, and to what extent the Nation's urban regions can begin to construct rapidly a relatively large amount of low-cost, and therefore, innovative housing—the characteristics of which are responsive to the fundamental, social, and economic needs of the Nation's lower income families.

W. A. Allen of Bickerdike, Allen, Rich and Partners of London, England, summarized the talks presented and gave his opinions of future developments and trends. Characterizing the present situation in this country as one of tremendously rapid change, he called for increased research and development to correct the mistakes of the past and to rapidly provide the proper shelter and amenities for our population. He said the industries and professions are beginning to shift to a more responsible position to meet these problems and was generally confident that much progress could and would be made.

Tentative topics for subsequent conferences include Modular Coordination; Cost and Evaluative Systems; Fire Research and Safety; Materials—New Ideas and Approaches; User Needs; and Building Codes.

[1] USASI Committee A62 approves a systems module standard for buildings, NBS Tech. News Bull. **52**, No. 9, 199 (Sept. 1968).

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## SOUND BUILDING *continued*

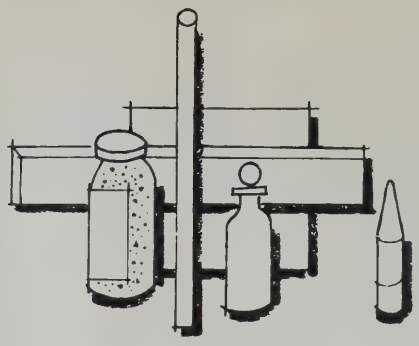
it from reaching other parts of the building. In addition to the double-wall and floating-floor construction in these areas, flexible couplers, resilient hangers, vibration isolators, and dampers, as well as sound-insulated and acoustically-treated enclosures, were used extensively in the installation of all heating, air-conditioning, plumbing, and electromechanical equipment, including the mounting of all ductwork, piping, conduits, or service lines emanating from such equipment or systems. For example, the heating, air-conditioning, and ventilation system was specially designed for nonturbulent, low-velocity, and low-pressure operation to eliminate generation of air-flow noise. The largest fans are enclosed in acoustically lined vibration-damped calming chambers. All other fans, blowers, pumps, and motors are mounted on large concrete slabs that are supported on resilient springs or rubber mounts.

The duct system throughout the building was specially designed and constructed of double-wall, acoustically treated construction for high sound-insulating and sound-absorbing efficiency. Resilient hangers support the entire system; and at points of penetration through walls, ceilings, and floors the ducts are encased in soft sponge-rubber gaskets to provide an air-tight seal and prevent the transmission of vibrational energy to the building structure.

The large power transformers and high-pressure steam valves, which usually are exceedingly noisy and troublesome devices, are housed in an underground concrete vault located about 100 feet east of the building. All penetrations through the roof for ventilation purposes are acoustically protected against the intrusion of noise from aircraft, traffic, and other outdoor sources. The location of the building and its orientation on the site were carefully selected to minimize the intrusion of noise from these sources.

Thus, virtually every vibration-isolating technique and noise-control measure, within budgetary limits, was used in the construction of the building. In most cases, the acoustical performance specifications of the building were met. The successful performance was largely due to close supervision and monitoring during building construction and to inspection of building materials before use.

# STANDARD REFERENCE MATERIALS



*Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems, or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.*

The NBS Office of Standard Reference Materials has added two new deuterium-labeled hydrocarbon standards and a new boron isotopic standard to the more than 650 standard reference materials it disseminates to science and industry for use in calibrating equipment and controlling quality. The gas-furnace black standard has been renewed, and a final certificate has been issued to replace the provisional one for the benzoic acid calorimetric standard.[1]

## Boron Isotopic Standard

The new boron isotopic standard is a boric acid of high purity and homogeneity for use in calibrating equipment and measuring the cross section of the boron(n,$\alpha$)-lithium [B(n,$\alpha$)Li] reaction. This cross section, particularly at thermal neutron energy (corresponding to a velocity of 2200 m/s), is one of the most important standard neutron cross sections used to calibrate equipment that measures neutron flux density.

The new boron isotopic standard, SRM 951, was prepared from a lot of boric acid that is uniform in isotopic composition and that adjusts to a stoichiometric composition after about 30 minutes exposure to normal room humidity (approximately 35 percent relative humidity). An additional boron isotopic standard, SRM 952, enriched in boron-10, is being prepared and will be available in January 1969. Additional details will be provided in a later *Technical News Bulletin.*

The boric acid from which SRM 951 was prepared has an acidimetric assay of 100.00$\pm$0.02 weight percent and an absolute abundance ratio of $^{10}B/^{11}B$ of 0.2473$\pm$0.0002.

The assay was performed by coulometric titration of samples varying in size from 0.2 to 1.0 g of boric acid, dissolved in 100 ml of a preneutralized solution 1 *M* in potassium chloride and 0.75 *M* in mannitol. The inflection point of the potentiometric curve obtained from measurements with a glass-calomel electrode system was taken as the end point. The pH of the maximum inflection point will vary from approximately 7.9 to 8.5 for the range of sample sizes given above. The titration was conducted in the absence of carbon dioxide. The indicated tolerance is at least as large as the 95 percent confidence level for a single determination of any sample in the lot of material. The average essentially indicates a boron-hydrogen ion ratio of 1.0000, as separate examination shows the material contains less than 0.001 percent of free strong acid.

The abundance ratio was determined by single filament solid-sample mass spectrometry, using the ion $Na_2BO_2^+$. Mixtures of known $^{10}B/^{11}B$ ratio (at 1:4, 1:1, and 4:1 ratios) were prepared from high-purity separated isotope solutions and were used as comparison standards. A correction was made for the $^{16}O/^{17}O$ ratio ($^{11}B/^{10}B$ ratio $-0.000\,79$). The limits of error are based on 95 percent confidence limits for the mean of the ratio measurements and on allowances for the known sources of possible systematic error.

The material was prepared by the J. T. Baker Company of Phillipsburg, N.J., for the Argonne National Laboratory. Separated isotopes were purified and solutions prepared by K. M. Sappenfield and T. J. Murphy, coulometric titrations were made by G. Marinenko and C. E. Champion, mass spectrometry measurements were made

by E. J. Catanzaro and E. L. Garner, all of whom are members of the NBS Analytical Chemistry Division. The various procedures developed are being prepared in full detail for publication.

The overall direction and coordination of the technical measurements leading to certification were performed under the chairmanship of W. R. Shields, also of the NBS Analytical Chemistry Division. The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated by J. L. Hague of the NBS Office of Standard Reference Materials.

The boron isotopic standard, SRM 951, is available in units of approximately 100 grams for $50 per unit.[2]

## Deuterium-Labeled Ethane and Propane Standards

In kinetic studies in which deuterium labeling of the reactants is used, as in pyrolysis or photolysis studies, the reaction products contain partially deuterated molecules as reaction products.

To describe the isotopic structure of these molecules, comparison mass spectrometric cracking patterns should be determined in the same mass spectrometer in which the product is to be analyzed because each commercial mass spectrometer shows a different behavior. For this reason deuterated standard reference materials that meet the special characteristics required for mass spectrometric work are needed. These compounds must be chemically pure, the "isotopic impurity" must be known, and the position of the deuterium atoms in the molecule must be well characterized in order to trace reaction mechanisms and to obtain accurate rate data.

In deuterium labeled ethane ($CD_3CD_3$), SRM 2175 has a chemical purity greater than 99.9 mole percent and an isotopic purity of 99.8 $\pm$0.05 atom percent deuterium. The deuterium labeled propane ($CH_3CH_2CD_3$), SRM 2176, also has a chemical purity greater than 99.9 mole percent. Its isotopic purity is 99.4 $\pm$0.2 mole percent $CH_3CH_2CD_3$.

The chemical purity of both compounds was determined by use of a gas chromatograph equipped with a flame ionization detector and a 6-foot alumina column. The only detectable impurity in the ethane was approximately 0.002 mole percent propane. The impurities in the propane were approximately 0.03 mole percent ethane and approximately 0.01 mole percent ethylene.

The isotopic purity of the ethane was determined by mass spectrometry while that of the propane was calculated from the purity of the starting material.

The new standard reference materials were prepared, purified, and characterized by P. J. Ausloos, R. E. Rebbert, and R. M. David of the NBS Radiation Chemistry Section.

The new standards may be purchased [2] in units of 5 ml sealed ampoules for prices as follows:

SRM 2175, Ethane, -$d_6$, $CD_3CD_3$, $315 per unit.

SRM 2176, Propane, -1,1,1-$d_3$, $CH_3CH_2CD_3$, $1150 per unit.

## Gas-Furnace Black Standard

The rubber used in manufactured goods is made by processes in which various materials are worked into the raw elastomer. These elastomers, in crude form, vary from lot to lot, and the principal strengthener-fillers—the commercial carbon blacks—are not completely homogeneous.

A uniform, high quality rubber product is manufactured from these nonhomogeneous raw materials by continually testing and monitoring the production batches using standard reference materials.

Gas furnace black, SRM 382a, is one of these materials. It is highly uniform with respect to particle size, surface area, and compactibility and is similar to the earlier lot of SRM 382, which it replaces. It can be used in all rubber test recipe evaluations for which SRM 382 was used.

Supplied in units of four cans, each containing 7500 grams, SRM 382a costs $47.[2]

## Benzoic Acid Calorimetric Standard

The benzoic acid calorimetric standard, SRM 391, which has been available under a provisional certificate prepared on the basis of comparative combustion calorimetry, is now available with an absolute calibration made by electrical means.

The benzoic acid from which SRM 39i was prepared conforms to the American Chemical Society specification for reagent-grade benzoic acid. Freezing point measurements indicate the purity is about 99.997 mole percent.

The quantity of energy involved by combustion of SRM 39i when burned under standard bomb conditions is 26 434 J $g^{-1}$ with an estimated uncertainty of 3 J $g^{-1}$.

Heat measurements leading to the certification of SRM 39i were performed by K. Churney. The overall direction and coordination of the technical measurements were performed under the supervision of G. T. Armstrong. This standard is available in units of 30 grams for $21.[2]

[1] For a complete list of Standard Reference Materials available from NBS, see Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, NBS Misc. Publ. 260 (1968 ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

[2] These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

**Coming next month . . .**

**New Metric Chart**

The January TNB will feature a full color reproduction of the new metric chart prepared by NBS. It is one-third the size of the actual chart and provides a handy reference for students and professionals alike.

# PUBLICATIONS of the National Bureau of Standards*

## PERIODICALS

*Technical News Bulletin*, Volume 52, No. 11, November 1968, 30 cents. Annual subscription: Domestic, $3; foreign, $4. Available on a 1-, 2-, or 3-year subscription basis.

*Journal of Research of the National Bureau of Standards*

*Section A. Physics and Chemistry.* Issued six times a year. Annual subscription: Domestic, $6; foreign, $7.25. Single copy, $1.

*Section B. Mathematical Sciences.* Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

*Section C. Engineering and Instrumentation.* Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

## CURRENT ISSUES OF THE JOURNAL OF RESEARCH

*J. Res. NBS* **72B** *(Math. Sci.)*, No. 4 (Oct.–Dec. 1968), 75 cents.

Goldman, A. J., Minimax error selection of a discrete univariate distribution with prescribed componentwise ranking.

Goldman, A. J., and Meyers, P. R., Minimax error selection of a discrete univariate distribution with prescribed componentwise bounds.

Hearon, J. Z., Generalized inverses and solutions of linear systems.

Lehner, J., On the multipliers of the Dedekind modular function.

Reudink, D. O., On the signs of the $\nu$-derivatives of the modified Bessel functions $I_\nu(x)$ and $K_\nu(x)$.

Thompson, R. C., Principal submatrices VII: Further results concerning matrices with equal principal minors.

Torrance, K. E., Comparison of finite-difference computations of natural convection.

*J. Res. NBS* **72C** *(Engr. and Instr.)*, No. 4 (Oct.–Dec. 1968), 75 cents.

Hettche, L. R., Theoretical and experimental study on longitudinal impact of tappered rods.

Mitchell, R. A., and Kaplan, K. L., Nonlinear constrained optimization by a nonrandom complex method.

Peavy, B. A., Analytical studies of probe conduction errors in ground temperature measurements.

## OTHER NBS PUBLICATIONS

Davis, M. M., Acid-base behavior in aprotic organic solvents, Mono. 105 (Aug. 1968), $2.25.

deMaine, P. A. D., Input/output packages for the systems 360 assembly language processor, Tech. Note 433 (Sept. 1968), 25 cents.

Eisele, J. W., Tech. Std. Coordinator, Fabrics for book covers, PS 9-68 (Apr. 1968), 10 cents.

Fraction, G. F., Walker, J. C., and Tauber, S. J., Connection tables from Wiswesser chemical structure notations—a partial algorithm, Tech. Note 432 (Sept. 1968), 65 cents.

Goldman, D. T., Ed., Neutron cross sections and technology, Proc. Conf., Washington, D.C., Mar. 4–7, 1968, Spec. Publ. 299 (Sept. 1968), $10.50 set of 2 volumes.

Heinrich, K. F. J., Ed., Quantitative electron probe microanalysis, Proc. Seminar, National Bureau of Standards, Gaithersburg, Md., June 12–13, 1967, Spec. Publ. 298 (Oct. 1968), $3.

Johnston, H. S., Gas phase reaction kinetics of neutral oxygen species, NSRDS–NBS–20 (Sept. 1968), 45 cents.

Lovell, W. S., and Thiel, L. M., Interferometric measurements of the complex dielectric constant of liquids, Tech. Note 369 (Aug. 1968), 50 cents.

Menis, O., Ed., Analytical Coordination Chemistry Section: Summary of activities July 1967 to June 1968, Tech. Note. 454 (July 1968), 55 cents.

Moore, C. E., Bibliography on the analyses of optical spectra. Section 1. $^{1}$H–$^{23}$V, Spec. Publ. 306 (Sept 1968), $1.

Muhlenhaupt, R. C., and Strobridge, T. R., An analysis of the Brayton cycle as a cryogenic refrigerator, Tech. Note 366 (Aug. 1968). $1.25.

Scribner, B. F., Ed., Spectrochemical Analysis Section: Summary of Activities July 1967 to June 1968, Tech. Note 452 (Sept. 1968). $1.

Swindells, J. F., Ed., Precision measurement and calibration. Selected NBS papers on temperature, Spec. Publ. 300, Vol. 2 (Aug. 1968), $4.75.

## PUBLICATIONS IN OTHER JOURNALS

*This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.*

Mahler, R. J., and James, L. W., Nuclear electric hexadecapole-phonon interaction (Proc. XIV Colloque Ampere, Sept. 6–11, 1966, Ljubljana, Yugoslavia), Book, Magnetic Resonance and Relaxation, Ed. R. Blinc, pp. 938–945 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1967).

Maryott, A. A., and Birnbaum, G., Line shape and collision effects in the microwave wing of far-infrared rotational lines, J. Chem. Phys. **47,** No. 9, 3200–3205 (Nov. 1967).

Mather, J. N., Invariance of the homology of a lattice, Proc. Am. Math. Soc. **17,** No. 5, 1120–1124 (Oct. 1966).

Melmed, A. J., Field emission microscopy, Book, Advances in Materials Research, Volume I. Experimental Methods, Ed. H. Herman, pp. 103–143 (Interscience Publ., Inc., New York, N.Y., 1967).

Melmed, A. J., Whiskers, thin films, and applications (real and imagined) to mass spectrometry and biological molecule imaging, Book, Field-Ion Microscopy, Eds. J. J. Hren and S. Ranganathan, pp. 183–212 (Plenum Press, Inc., New York, N.Y., 1968).

Melmed, A. J., Layer, H. P., and Kruger, J., Ellipsometry, low energy electron diffraction and field emission microscopy combined, Surface Sci. **9,** 476–483 (1968).

Mies, F. H., Quantum oscillations in the shape of pressure-broadened atomic lines, J. Chem. Phys. **48,** No. 1, 482–494 (Jan. 1968).

Miller, K. J., and Krauss, M., Born inelastic differential cross sections in $H_2$, J. Chem. Phys. **47,** No. 10, 3754–3762 (Nov. 1967).

Miller, K. J., and Krauss, M., Inapplicability of the Born exchange scattering amplitude for the He ($1^1S \rightarrow 2^3S$) transition, J. Chem. Phys. **48,** No. 6, 2611–2614 (Mar. 1968).

Moiseiwitsch, B., and Smith, S. J., Electron impact excitation of atoms, Rev. Mod. Phys. **40,** No. 2, 238–353 (Apr. 1968).

Moore, G. A., Automatic scanning and computer processes for the quantitative analysis of micrographs and equivalent subjects (Proc. Symp. on Automatic Photo Interpretation, Washington, D.C., May 31–June 2, 1967), Book, Pictorial Pattern Recognition, Eds. G. C. Cheng, R. S. Ledley, D. K. Pollock, and A. Rosenfeld, pp. 275–326 (Thompson Book Co., Washington, D.C., 1968).

Mopsik, F. I., Molecular and ionic interactions, 1966 Digest of Literature on Dielectrics **30,** Chapter 3, 62–90 (National Academy of Sciences–National Research Council, Washington, D.C., 1966).

Motz, J. W., and Sparrow, J. H., A simple device for the energy and current measurement of an accelerator electron beam, Record of the IEEE 9th Arn. Symp. on Electron, Ion, and Laser Beam Technology, Berkeley, Calif., May 9–11, 1967, pp. 34–41 (San Francisco Press, Inc., San Francisco, Calif., May 1967).

Mountain, R. D., Relaxation times for the volume viscosity of simple fluids, J. Chem. Phys. **48,** No. 5, 2189–2190 (Mar. 1968).

Mountain, R. D., and Zwanzig, R., Anomalous transport properties of a van der Waals gas, J. Chem. Phys. **48,** No. 4, 1451–1458 (Feb. 1968).

Nargolwalla, S. S., Crambes, M. R., and DeVoe, J. R., A techniue for the evaluation of systematic errors in the activation analysis for oxygen with 14-MeV neutrons, Anal. Chem. **40,** No. 4, 666–671 (Apr. 1968).

Olver, F. W. J., An extension of Miller's algorithm, Aplikace Mat. **13,** 174–176 (1968).

Oppenheim, I., Shuler, K. E., and Weiss, G. H., On the decay of initial correlations in stochastic processes, J. Chem. Phys. **46,** No. 10, 4100–4111 (May 1967).

Osgood, C. F., A method in diophantine approximation (II), Acta Arith. **XIII,** 383–393 (1968).

Parker, R. L., Report on the 1966 Boston International Conference on Crystal Growth, Proc. 1966 Intern. Union Crystallography, Moscow, U.S.S.R., July 12–21, 1966, **7,** 341–354 (Academy of Sciences, Moscow, U.S.S.R., 1968).

Patty, O. L., Little, W. E., and Zanboorie, M. H., Waveguide connector measurements with a millimeter wave reflectometer, IEEE Trans. Microwave Theory Tech. **MTT–16,** No. 2, 121–123 (Feb. 1968).

Penner, S., Handling high power electron beams, IEEE Trans. Nucl. Sci. **NS–14,** 908 (June 1967).

Penney, R. W., and Phillips, C. W., Refrigeration requirements for truck bodies-effects of door usage, USDA Tech. Bull. No. 1375 (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Nov. 1967, 10 cents).

Persson, K.-B., Johnson, E. G., Jr., and Uhlenbrock, D. A., A theory for cyclotron harmonic radiation from plasmas, Phys. Fluids **1,** No. 3, 619–628 (Mar. 1968).

Peterson, R. L., Ising chain as the basic cluster in effective-field theories of magnetism, Phys. Letters **27A,** 177 (June 1968).

Peterson, R. L., Suppressed spin-lattice relaxation, Phys. Rev. Letters **20,** No. 24, 1346–1348 (June 1968).

Pichanick, F. M. J., and Simpson, J. A., Resonances in the total cross sections for metastable excitation of noble gases by electron impact, Phys. Rev. **168,** No. 1, 64–70 (Apr. 1968).

Preston, G. T., Chapman, T. W., and Prausnitz, J. M., Transport properties of cryogenic liquids and their mixtures, Cryogenics **7,** No. 5, 274–279 (Oct. 1967).

Pytte, E., and Bennett, H. S., Ultrasonic attenuation in the Heisenberg paramagnet. II. Anti-ferromagnets, Phys. Rev. **164,** No. 2, 712–715 (Dec. 1967).

Radford, H. E., and Evenson, K. M., Paramagnetic resonance spectrum of metastable ($^2$D) atomic nitrogen, Phys. Rev. **168,** No. 1, 70–74 (Apr. 1968).

Rebbert, R. E., and Ausloos, P., Photolysis of methyliodide in matrices of organic compounds at 20° and 77° K. Reactions of hot methyl radicals, J. Chem. Phys. **48,** No. 1, 306–311 (Jan. 1968).

Reimann, C. W., and Zocchi, M., The structure of the trinuclear cation bis-[$\mu$-(tri-1,2,4-triazolo-N$^1$,N$^2$)-triquonickel]nickel, Chem. Commun. **5,** 272 (Mar. 1968).

Roder, H. M., The thermal conductivity of helium gas at moderate pressures, Proc. Thermodynamik Symp., Heidelberg, Germany, Sept. 1967, Sponsored by the International Union of Pure and Applied Chemistry, Ed. K. L. Schafer, Paper No. VI–3, pp. 1–8 (1968).

Ronn, A. M., Laser induced infrared fluorescence, J. Chem. Phys. **48,** No. 1, 511–513 (Jan. 1968).

Rybicki, G. B., and Hummer, D. G., Spectral line formation in variable-property media: The Riccati method, Astrophys. J. **150,** No. 2, 607–635 (Nov. 1967).

Scribner, B. F., Advances in excitation sources for spectrochemical analysis, Pure Appl. Chem. **10,** 579–594 (July 1967).

Sengers, J. V., Triple collision contribution to the transport coefficients of gases (Lectures presented at the Theoretical Physics Institute, University of Colorado, Boulder, Summer 1966), Book, Lectures in Theoretical Physics, Vol. IX–C. Kinetic Theory, Ed. W. E. Brittin, pp. 335–374 (Gordon and Breach, New York, N.Y., 1967).

Shuler, K. E., Microscopic and macroscopic approach to chemical rate processes (Proc. 7th AGARD Colloquium, Oslo, Norway, May 16–20, 1966), Book, Recent Advances in Aerothermochemistry, Ed. I. Glassman, **1,** No. 12, 1–21 (Technical Editing and Reproduction Ltd., London, England, 1967).

Simmon, J. H., and Macedo, P. B., High temperature shear ultrasonic interferometer using sensitive phase-lock detection system, J. Acoust. Soc. Am. **43,** No. 6, 12 (June 1968).

Spijkerman, J. J., Hall, H. L., and Lambert, J. L. Coordination studies by Mössbauer spectroscopy of some metal(I) salts of the complex acid, hydrogen aquoethylenediaminetetraacetatoferrate (III), J. Am. Chem. Soc. **90,** No. 8, 2039–2042 (Apr. 1968).

Spokas, O. E., The NBS linac master control and personnel protection system, IEEE Trans. Nucl. Sci. **NS–14,** 1016 (June 1967).

Stern, J., Activities of the Basic Instrumentation Section (Proc. 5th Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3–4, 1967), Telemetry Working Group Document 112–68, 13–15 (Secretariat, Range Commanders Council, White Sands Missile Range, N. Mex., 1968).

Stern, J., Aspect systems, Encyclopedia of Library and Information Science **1,** 3200 (1967).

Sukle, D. J., and Wells, J. S., EPR sample orientation servo, Rev. Sci. Instr. Notes **39,** No. 4, 604–605 (Apr. 1968).

Swanson, N., and Powell, C. J., Excitation of L-shell electrons in Al and $Al_2O_3$ by 20-keV electrons, Phys. Rev. **167,** No. 3, 592–600 (Mar. 1968).

Tauke, J., Litovitz, T. A., and Macedo, P. B., Viscous relaxation and non-Arrhenius behavior in $B_2O_3$, J. Am. Ceram. Soc. **51,** No. 3, 158–163 (Mar. 1968).

Tisone, G. C., and Branscomb, L. M., Detachment of electrons from $H^-$ and $O^-$ negative ions by electron impact, Phys. Rev. **170,** No. 1, 169–183 (June 1968).

Van Blerkom, D., and Hummer, D. G., The ionization structure of planetary nebulae—VI. The Lyman continuum problem, Monthly Notices Roy. Astron. Soc. **137,** 353–374 (1967).

VanderHart, D. L., Gutowsky, H. S., and Farrar, T. C., Dipole-dipole interactions of a spin ½ nucleus with a quadrupole-coupled nucleus, J. Am. Chem. Soc. **89,** No. 19, 5056–5057 (Sept. 1967).

Van Reuth, E. C., and Waterstrat, R. M., Atomic ordering in binary A15-type phases, Acta Cryst. **B24,** Part 2, 186–196 (Feb. 1968).

Vriens, L., Kuyatt, C. E., and Mielczarek, S. R., Tests of Born approximations; differential and total cross sections for elastic scattering of 100- to 400-eV electrons by helium, Phys. Rev. **170.** No. 1, 163–169 (June 1968).

Wachtman, J. B., Jr., Brower, W. S., and Farabaugh, E. N., Elastic constants of single crystal calcium molybdate ($CaMoO_4$), J. Am. Ceram. Soc. **51,** No. 6, 341–344 (June 1968).

Wassink, H. W., Cyclotron harmonic emission along the field from a plasma, Phys. Fluids **11,** No. 3, 629–637 (Mar. 1968).

**Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign postage, one-fourth additional). The NBS nonperiodical series are also available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151. Reprints from outside journals and the* NBS Journal of Research *may often be obtained directly from the authors.*

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